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Applicant: ULVAC JAPAN, Ltd.

(54) [Title of the Invention] ORGANIC THIN FILM FORMING APPARATUS AND METHOD OF REUSING ORGANIC MATERIAL

(57) [Abstract]

[Object] There is provided an organic thin film forming apparatus in which an organic material adhered to a shutter for shielding steam from an organic material evaporation source can be easily recovered, and an organic material reusing method.

[Solving Means] An organic thin film forming apparatus of the present invention has an organic material evaporation sources 3 for evaporating an organic material 14 in a vacuum chamber 2 to form an organic thin film on a substrate, and shutters 4 for shielding and containing steam of the organic material 14 evaporated from the organic material evaporation source 3 until a predetermined evaporation rate is reached. The organic material 14 adhered to the shutters 4 is heated by a heater 5 to reevaporate it, the steam is cooled by a shroud 7 through

which a cooling medium 71 is circulated, and then captured and held in a holding portion 70. According to the present invention, an organic material for forming an organic EL element with a high purity can be reused.

[Claims]

[Claim 1] An organic thin film forming apparatus, characterized by comprising:

an evaporation source for evaporating a predetermined organic material in a vacuum chamber to form an organic thin film on a substrate;

a shutter for shielding and containing steam of the organic material evaporated from the evaporation source until a predetermined evaporation rate is reached;

heating means for heating the organic material adhered to the shutter to reevaporate it; and

holding means for capturing and holding the organic material evaporated from the shutter.

[Claim 2] The organic thin film forming apparatus according to claim 1, characterized in that the holding means has cooling means for cooling the steam in the vacuum chamber.

[Claim 3] The organic thin film forming apparatus according to claim 2, characterized in that the holding means has cooling means for cooling the steam in the vacuum chamber by using liquid nitrogen.

[Claim 4] The organic thin film forming apparatus according to any one of claims 1 to 3, characterized in that the predetermined organic material is an organic compound monomer for forming an organic electroluminescence element.

[Claim 5] A method of reusing an organic evaporation material, in an organic thin film forming apparatus for shielding and containing steam of a predetermined organic material evaporated from an evaporation source for a vacuum evaporation by a shutter until a predetermined evaporation rate is obtained, the method is characterized in that the organic material adhered to the shutter is heated for reevaporation, and then the organic material is captured and held to reuse it as an evaporation material.

[Claim 6] The method of reusing an organic evaporation material according to claim 5, characterized in that the steam of the organic material reevaporated from the shutter is cooled to capture and hold it.

[Claim 7] The method of reusing an organic evaporation material according to claim 6, characterized in that the steam of the organic material is cooled by using liquid nitrogen.

[Claim 8] The method of reusing an organic evaporation material according to any one of claims 5 to 7, characterized in that the predetermined organic material is an organic compound monomer for forming an organic electroluminescence element.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention belongs]

The present invention relates to an organic thin film forming apparatus for forming an evaporation film of an organic compound on a substrate, for example, in the case where an organic EL (electroluminescence) element or the like is manufactured, and an organic material reusing method.

[0002]

[Prior Art]

Conventionally, a semiconductor-based electronics has been developed with an inorganic as a research subject. However, recently, a functional thin film using an organic compound is gathering attention. The reasons that the organic compound is used are as follows:

(1) More various reaction systems and characteristics can be utilized in comparison with an inorganic.

(2) A surface processing can be performed with a lower energy than that with the inorganic.

[0003]

As such a functional thin film, there are an organic EL element, a piezoelectric sensor, a pyroelectric sensor, an electrical insulating film, and the like. Such a functional thin film is formed mainly by evaporation. However, of those, in particular, the organic EL element can be used as a display panel. Thus, the expansion of an area of a film formed by evaporation is required.

[0004]

Fig. 5 shows a schematic structure of a conventional organic thin film forming apparatus. As shown in Fig. 5, this organic thin film forming apparatus 100 has a vacuum chamber 101 connected with a vacuum exhaust system (not shown). A plurality of organic material evaporation sources 102A and 102B are disposed on both sides of a partition plate 103 interposed therebetween at introduction portions 101A and 101B which are provided in the lower portion of this vacuum chamber.

[0005]

Shutters 104A and 104B for containing steam of the organic material are respectively provided in the vicinities above of the organic material evaporation sources 102A and 102B. Film thickness monitors 105A and 105B for measuring a film formation rate are provided in the vicinities above of the shutters 104A and 104B.

[0006]

On the other hand, a substrate 106 on which an evaporation film is to be formed is disposed in the upper portion of the vacuum chamber 101. Also, a heating means 108 having a heating portion 107 is provided over a substrate 54 to contact the substrate 106. Further, a main shutter 109 for shielding the steam of the organic material is provided under the substrate 106.

[0007]

When the evaporation is performed on the substrate 106 using this organic thin film forming apparatus 100, the vacuum exhaust in the vacuum chamber 101 is made. Then, with the state that the shutters 104A and 104B and the main shutter 109 are closed, the organic materials in the organic material evaporation sources 102A and 102B are heated at a predetermined temperature.

[0008]

After the temperature of the respective organic materials reaches the predetermined temperature to obtain a predetermined amount of evaporation, the shutters 104A and 104B and the main shutter 109 are opened, and then the organic materials are evaporated and deposited on the substrate 106 at a predetermined deposition rate to form an organic thin film having a predetermined thickness. After that, the shutters 104A and 104B and the main shutter 109 are closed.

[0009]

[Problems to be solved by the Invention]

However, in the case of the conventional organic thin film forming apparatus 100, it is necessary to close the shutters 104A and 104B until the temperature of the organic materials in the organic material evaporation sources 101A and 101B reaches the predetermined temperature to obtain the

predetermined amount of evaporation. Therefore, there is a problem that the organic materials are adhered onto the rear surfaces of the shutters 104A and 104B, that is, the surfaces opposing the organic material evaporation sources 101A and 101B.

[0010]

If the organic materials adhered onto the rear surfaces of the shutters 104A and 104B are left as is, these organic materials rise as powder by a vibration due to the opening and closing of the shutters 104A and 104B. As a result, there is the case where the evaporation film with a uniform thickness is not obtained. Therefore, in the conventional apparatus, the shutters 104A and 104B need to be frequently cleaned.

[0011]

Also, conventionally, the organic materials adhered onto the rear surfaces of the shutters 104A and 104B have been discarded. However, some of such organic materials are expensive and the organic materials reevaporated in a vacuum are refined in many cases. Therefore, the reuse of such organic materials has been desired.

[0012]

The present invention has been made to solve the problem of such a conventional technique, and an object is to provide an organic thin film forming apparatus in which the organic

material adhered to the shutter for shielding steam from the organic material evaporation source can be easily recovered, and an organic material reusing method.

[0013]

[Means for Solving the Problem]

To achieve the above object, the invention according to claim 1 is an organic thin film forming apparatus characterized by comprising: an evaporation source for evaporating a predetermined organic material in a vacuum chamber to form an organic thin film on a substrate; a shutter for shielding and containing steam of the organic material evaporated from the evaporation source until a predetermined evaporation rate is obtained; heating means for heating the organic material adhered to the shutter to reevaporate it; and holding means for capturing and holding the organic material evaporated from the shutter.

[0014]

In this case, as the invention according to claim 2, in the invention according to claim 1, it is effective that the holding means has cooling means for cooling the steam in the vacuum chamber.

[0015]

Also, as the invention according to claim 3, in the invention according to claim 2, it is effective that the

holding means has cooling means for cooling the steam in the vacuum chamber by using liquid nitrogen.

[0016]

Further, as the invention according to claim 4, in the invention according to any one of claims 1 to 3, it is particularly effective in the case where the predetermined organic material is an organic compound monomer for forming an organic electroluminescence element.

[0017]

On the other hand, the invention according to claim 5 is a method of reusing an organic evaporation material, in an organic thin film forming apparatus for shielding and containing steam of a predetermined organic material evaporated from an evaporation source for vacuum evaporation by a shutter until a predetermined evaporation rate is obtained, the method is characterized in that the organic material adhered to the shutter is heated for reevaporation, and then the organic material is captured and held to reuse it as an evaporation material.

[0018]

In this case, as the invention according to claim 6, in the invention according to claim 5, it is effective that the steam of the organic material reevaporated from the shutter is cooled to capture and hold it.

[0019]

Also, as the invention according to claim 7, in the invention according to claim 6, it is effective that the steam of the organic material is cooled by using liquid nitrogen.

[0020]

Further, as the invention according to claim 8, in the invention according to any one of claims 5 to 7, it is particularly effective in the case where the predetermined organic material is an organic compound monomer for forming an organic electroluminescence element.

[0021]

In the case of the invention according to claim 1 with the above structure, the organic material adhered to the shutter is heated by the heating means, and then the evaporated organic material is captured and held by the holding means. Thus, the surface of the shutter opposing the organic material evaporation source can be made to become the state that the organic material is not easily adhered thereto. As a result, in the film formation, there is no case where the organic material rises as powder by a vibration due to the opening and closing of the shutter. Also, it is unnecessary to frequently clean the shutter.

[0022]

In this case, as the invention according to claim 2, the

holding means has the cooling means for cooling the steam in the vacuum chamber, and in particular, as the invention according to claim 3, the holding means is constructed such that the steam is cooled by using liquid nitrogen, so that the steam of the organic material is easily captured.

[0023]

Also, as the invention according to claim 5, when the organic material adhered to the shutter is heated for reevaporation and then the organic material is captured and held to reuse it as an evaporation material, since the organic material adhered to the shutter is produced by evaporation in a vacuum, it is refined in many cases. Thus, the organic evaporation material with a high purity can be obtained.

[0024]

In this case, as the invention according to claim 6, the steam of the organic material reevaporated from the shutter is cooled to capture and hold it, and in particular, as the invention according to claim 7, the steam of the predetermined organic material is cooled by using liquid nitrogen. Thus, the steam of the organic material is easily captured and a recovery rate of the organic material is improved.

[0025]

Also, as the invention according to claim 4 or 8, When the predetermined organic material is the organic compound

monomer for forming the organic electroluminescence element, the case where an expensive material is wasted does not arise.

[0026]

[Embodiment Mode of the Invention]

Hereinafter, a preferred embodiment of an organic thin film forming apparatus and an organic material reusing method according to the present invention will be described in details with reference to Figs. 1 to 4.

[0027]

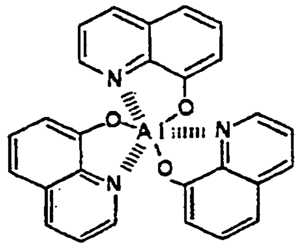
Fig. 3 shows one example of the organic thin film forming apparatus according to this embodiment. As shown in Fig. 3, this organic thin film forming apparatus 1 has a vacuum chamber 2 connected with a vacuum exhaust system (not shown) such as a cryopump. Organic material evaporation sources 3 (3A and 3B) are disposed to interpose a partition plate 15 in a plurality of introduction portions 2A and 2B which are provided in the lower portion of the vacuum chamber 2.

[0028]

The insides of the organic material evaporation sources 3A and 3B are filled with various materials including Alq_3 [tris (8-hydroxyquinolate) aluminum sublimed] as an organic compound oligomer for manufacturing, for example, an organic EL element.

[0029]

[CHEM 1]



Alq3

[0030]

Shutters 4 (4A and 4B) for containing steam of an organic material are provided in the upper side vicinities of the respective organic material evaporation sources 3A and 3B. Heaters 5 (5A and 5B) for heating the organic material mentioned later are provided above these shutters 4A and 4B. Note that, film thickness monitors 6 (6A and 6B) for measuring a film formation rate are provided in the vicinities above of the respective shutters 4A and 4B.

[0031]

Also, a shroud 7 is provided around the respective organic material evaporation sources 3A and 3B. This shroud 7 is structured such that liquid nitrogen are circulated through the inside, as mentioned later. Also, the shroud 7 has a function for capturing moisture around the respective organic material evaporation sources 3A and 3B and steam of the organic material 14 reevaporated from the shutters 4A and 4B.

[0032]

On the other hand, a substrate 8 on which an evaporation film is to be formed is disposed in the upper portion of the

vacuum chamber 2. Also, a heating portion 10 having, for example, a hot water pipe 9 for heating is provided over and contacting the substrate 8. Further, a main shutter 11 for shielding the steam of the organic material is provided under the substrate 8.

[0033]

Also, a shroud 12 is provided to surround the substrate 8 and the main shutter 11 in the vicinities of side walls of the vacuum chamber 2. This shroud 12 is structured such that liquid nitrogen and the like are circulated through the inside. Also, the shroud 12 has a function for capturing moisture around the substrate 8 and the steam of the organic material 14 reevaporated from the inner wall of the vacuum chamber 2.

[0034]

Further, gas introduction means 13 for introducing an inert gas such as a nitrogen gas into the vacuum chamber 2 is connected with the vacuum chamber 2.

[0035]

Fig. 1 shows substantial parts of this embodiment. Fig. 1(a) is a schematic view representing a structure of the shutter 4 and its vicinities. Fig. 1(b) is an explanatory view showing a method of reusing the organic material adhered to the shutter 4.

[0036]

As shown in Fig. 1(a), the shutter 4 which is provided over the organic material evaporation source 3 is attached to a support 41 by an arm 40, and thus can be rotated freely in a horizontal direction. The heater 5 which is provided on the upper surface of the shutter 4 is connected with a power source unit 51 which is provided outside the vacuum chamber 2, through a lead wire 50.

[0037]

The shutter 4 is composed of, for example, a disk-shaped member made of high melting point metal such as titanium (Ti) or molybdenum (Mo). A mirror surface is formed on the lower surface of the shutter 4.

[0038]

On the other hand, as shown in Fig. 1(b), the inside of the shroud 7 which is provided around the organic material evaporation source 4 is filled with a cooling medium 71 such as liquid nitrogen. Also, a holding portion 70, made from a concave portion, for recovering the organic material 14 adhered onto the lower surface of the shutter 4 is formed on the upper surface of shroud 7.

[0039]

Then, as shown in Fig. 2, the shutter 4 is constructed so as to move between the upper side of the organic material evaporation source 3 and the upper side of the holding portion

70 of the shroud 7. In this case, the shutter 4 is disposed extremely near the holding portion 70 of the shroud 7.

[0040]

Further, as shown in Figs. 1 and 2, the holding portion 70 of the shroud 7 is structured so as to have a circular shape with a larger diameter than that of the shutter 4, and to have a larger diameter than that of the organic material evaporation source 3.

[0041]

Fig. 4 shows a positional relationship among the organic material evaporation sources 3, the shutters 4, and the holding portions 70 of the shrouds 7. As shown in Fig. 4, there is the case where a plurality of (three in the example shown in Fig. 4) organic material evaporation sources 3 (3A, 3B, and 3C) each having the same structure are provided in the vacuum chamber 2, a plurality of (three in the example) shutters 4 (4A, 4B, and 4C) each having the same structure are provided therein, and a plurality of (three in the example) shrouds 7 (7A, 7B, and 7C) each having the same structure are provided therein. In this case, the organic material evaporation sources 3A, 3B, and 3C, the shutters 4A, 4B, and 4C, and holding portions 70A, 70B, and 70C of the shrouds 7A, 7B, and 7C are concentrically arranged. The respective shutters 4A, 4B, and 4C are constructed so as to move between

the upper sides of the organic material evaporation source 3A, 3B, and 3c and the upper sides of the holding portions 70A, 70B, and 70C by the rotation of the support 41.

[0042]

In this embodiment with such a structure, when the organic thin film is formed on the substrate 8, after a vacuum exhaust in the vacuum chamber 2 is performed such that the pressure in the vacuum chamber 2 reaches a predetermined pressure, the organic materials in the respective organic material evaporation sources 3 are heated at a predetermined temperature with the state that the shutters 4 and the main shutter 11 are closed.

[0043]

After the temperature of the organic materials in the respective organic material evaporation sources 3 reaches the predetermined temperature to obtain a predetermined amount of evaporation, the shutters 4 and the main shutter 11 are opened, and then the organic materials are evaporated and deposited on the substrate 8 at a predetermined deposition rate. Then, after an organic thin film having a predetermined thickness is formed, the shutters 4 and the main shutter 11 are closed.

[0044]

When such a vacuum evaporation is repeated, as shown in Fig. 1, the organic material 14 is adhered onto the lower

surface of the shutter 4 and deposited thereon. The organic material adhered to the shutter 4 can be recovered and reused using the following method.

[0045]

First, the inner pressure of the vacuum chamber 2 is returned to an atmospheric pressure. Then, as shown in Fig. 2, the shutter 4 is moved from the upper side of the organic material evaporation source 3 to dispose the upper side of the holding portion 70 of the shroud 7.

[0046]

Then, a current is passed through the heater 5 provided on the upper surface of the shutter 4 to heat the shutter 4, and thus the organic material 14 adhered onto the lower surface thereof is heated. In this case, the organic material 14 is heated at a temperature that the organic material 14 is evaporated (for example, about 350°C in the case of Alq_3).

[0047]

The steam of the evaporated organic material 14 is cooled in the surface of the shroud 7 to become a solid state, and then is captured in the holding portion 70 of the shroud 7. Thus, if this organic material is recovered, it can be used as the organic material for reevaporation.

[0048]

According to this embodiment with such a structure, the

lower surface of the shutter 4 can be made to become the state that the organic material 14 is not easily adhered thereto. As a result, the organic material 14 does not rise as powder by a vibration due to the opening and closing of the shutter 4 during the film formation. Therefore, the evaporation film with a uniform thickness can be always obtained. Also, the frequency of cleaning of the shutter 4 can be reduced.

[0049]

Also, since the organic material 14 adhered onto the lower surface of the shutter 4 is produced by the evaporation in the vacuum, it is refined in many cases. Thus, the organic evaporation material with a high purity can be obtained. Therefore, when this material is reused, the organic thin film with a further high quality can be formed.

[0050]

On the other hand, there is an expensive material as the organic material for forming the organic EL thin film. However, according to this embodiment, there is no case where the evaporation material is wasted, and thus the cost can be reduced.

[0051]

Note that, the present invention is not limited to the above embodiment, and various modifications can be made. For example, a pattern of the heater 5 provided on the shutter 4

can be made with various shapes. Also, various heaters such as an infrared lamp heater can be used as the heater 5.

[0052]

Also, a container for holding the organic material 14 can be provided separately from the shroud 7. As the above mentioned embodiment, when the holding portion 70 is provided on the upper surface of the shroud 7, a more compact structure can be obtained.

[0053]

Further, in the above embodiment, the liquid nitrogen as the cooling medium 71 is circulated through the inside of the shroud 7. However, for example, the structure may be such that cold water is circulated.

[0054]

Furthermore, the timing when the shutter 4 is heated to recover the organic material 14 can be arbitrarily set. However, it is difficult to capture the organic material 14 in a vacuum. Therefore, it is preferable, for example, to heat the shutter 4 in an atmosphere during the maintenance.

[0055]

Furthermore, the present invention is applied to not only an apparatus for manufacturing the organic EL element, but also, for example, to an apparatus for manufacturing an organic sensor and an apparatus for forming a polymer thin

film using evaporation polymerization. Of course, the present invention has a large effect for particularly an organic EL element manufacturing apparatus using an expensive organic material.

[0056]

[Effects of the Invention]

As described above, according to the present invention, the surface of the shutter opposing the organic material evaporation source can be made to become the state that the organic material 14 is not easily adhered thereto. The rise of the organic material by the vibration due to the opening and closing of the shutter during film formation can be prevented. Therefore, according to the present invention, the evaporation film with a uniform thickness can be always obtained. Also, the frequency of cleaning of the shutter can be reduced.

[0057]

Further, since the organic material adhered to the shutter is produced by the evaporation in the vacuum, it is refined in many cases. Thus, the organic evaporation material with a high purity can be obtained. Therefore, when this material is reused, the organic thin film with a further high quality can be formed.

[0058]

On the other hand, there is an expensive material as the

organic material for forming the organic EL thin film. However, according to the present invention, there is no case where the evaporation material is wasted, and thus the cost can be reduced.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 shows substantial parts of the organic thin film forming apparatus according to the present invention, Fig. 1(a) is a schematic view representing a structure of the shutter and its vicinities and Fig. 1(b) is an explanatory view showing a method of reusing the organic material adhered to the shutter.

[Fig. 2]

An explanatory view showing the movement of the shutter in the embodiment.

[Fig. 3]

A schematic view representing the entire structure of the embodiment.

[Fig. 4]

An explanatory view showing a positional relationship among the organic material evaporation sources, the shutters, and the holding portions of the shrouds in the embodiment.

[Fig. 5]

A schematic structure view of a conventional organic thin

film forming apparatus.

[Description of Symbols]

1 ... organic thin film forming apparatus, 2... vacuum chamber, 3(3A, 3B, 3C) ... organic material evaporation sources, 4(4A, 4B, 4C) ... shutters, 5(5A, 5B, 5C) ... heaters, 6A, 6B ... film thickness monitors, 7(7A, 7B, 7C) ... shrouds, 8 ... substrate, 9 ... hot water pipe, 10 ... heating portion, 11 ... main shutter, 12 ... shroud, 14 ... organic material, 50 ... lead wire, 51 ... power source unit, 70(70A, 70B, 70C) ... holding portions, 71 ... cooling medium.

film forming apparatus.

[Description of Symbols]

1 ... organic thin film forming apparatus, 2... vacuum chamber, 3(3A, 3B, 3C) ... organic material evaporation sources, 4(4A, 4B, 4C) ... shutters, 5(5A, 5B, 5C) ... heaters, 6A, 6B ... film thickness monitors, 7(7A, 7B, 7C) ... shrouds, 8 ... substrate, 9 ... hot water pipe, 10 ... heating portion, 11 ... main shutter, 12 ... shroud, 14 ... organic material, 50 ... lead wire, 51 ... power source unit, 70(70A, 70B, 70C) ... holding portions, 71 ... cooling medium.